

## SPECIFICATION

### TITLE

### WIRELESS TRANSMISSION SYSTEM FOR HEARING DEVICES

### BACKGROUND OF THE INVENTION

[0001] The present invention concerns a hearing device with a radio device to transmit signals, in particular to a second hearing device, whereby the radio device comprises an antenna device to send and/or receive. Furthermore, the present invention concerns a hearing device in which actions are implemented to decrease interfering signals, as well as a corresponding method to decrease interfering signals in hearing device receiving signals of the wireless transmission system.

[0002] In hearing device technology, the bidirectional, wireless coupling of hearing devices in binaural supply (i.e., providing each ear with respectively one hearing device) is a goal sought by many audiologists. Due to the spatial and energy limitations, however, the use of the previously known wireless transmission systems is impossible under real conditions. In particular, the realization of the function of the transmission from the hearing device could not previously be realized with maintainable energy use. In connection with this, hearing devices are known that possess a binaural coupling based on a wireless transmission link, whereby, however, unidirectional FM transmission systems with audio-bandwidth (CROS/BiCROS systems) and high energy expenditure are used. Such solutions are not viable, in particular for ITE (in-the-ear) hearing devices.

### SUMMARY OF THE INVENTION

[0003] The object of the present invention is thus to make available a wireless coupling of hearing devices with efficient energy use.

[0004] This object is inventively achieved by a hearing device with a radio device to transmit signals, in particular to a second hearing device, whereby the radio device comprises an antenna device to transmit and/or receive, and whereby the antenna device comprises a self-exciting oscillation circuit.

[0005] Furthermore, a hearing device is inventively provided with a receiving device to receive a plurality of values of at least one radio signal, whereby the

receiving device comprises a median filter device with which a median value of the plurality of values can be determined for reducing interference signals.

[0006] Finally, the object cited above is also achieved according to the present invention via a method to reduce noise signals in a hearing device receiving signals by receiving a plurality of values of at least one radio signal via a hearing device, and median filters of the plurality of values to acquire a median value for a noise signal reduction within the received radio signal.

[0007] Preferred embodiments of the invention are based in assembling a transmission link via which control data can be transmitted with a lower rate. This can be preferably realized via a half-duplex transmission link. Due to the effectiveness, the long-wave range should be used for the transmission. This is preferably realized via an inductive coupling with the respective other hearing device.

[0008] The use of a quartz oscillator for a frequency reference for data transmission is not possible in hearing devices for spatial reasons. Therefore, in the embodiments, the subsequently specified antenna oscillator is preferably consulted transmission-side as frequency-normal for the transmission system. In addition to establishing the transmission carrier frequency of the antenna oscillator, a bit timing (bitclock) can be derived for the transmitted data stream by subdividing the carrier frequency. An LC oscillator comprising a coil and a capacitance is preferably used as a transmission antenna that possesses a high quality, for example  $Q > 10$ . This LC oscillator ensures a high efficiency. This can, for example, in the case of transmission, be excited with low power and thereupon oscillates. The high reactive currents thereby ensuing provide for a good radiation of the coil (leakage inductance). For data transmission, this self-excited oscillation circuit can be detuned with regard to its resonance frequency, and thereby be used for frequency modulation.

[0009] On the receiving-side, a median filter device can be used for interference signal reduction after narrow-band filtering and digitalization. A median value is acquired with the median filter from a plurality of values that have a relatively small noise portion.

[0010] Due to the energy management, an embodiment provides for the communication via a half-duplex transmission line. A narrow-band signal transmission in the long-wave range results in a further energy advantage. As a rule, high bandwidths, as are necessary for the transmission of audio data, can be foregone here.

[0011] In the hearing device, the LC oscillation circuit can be used both for the generation of a carrier frequency to transmit and to clock the receiving device, in particular a filter device comprised therein. It is possible with this to form a quartz-independent transmission system. The data rate is thereby determined from the carrier frequency and a predetermined divider. The receiving device preferably first synchronizes to the carrier frequency, and the filtering, for example, width of the median filter, adaptively adjusts to the carrier frequency or, respectively, data rate, such that a suitable evaluation can ensue.

#### DESCRIPTION OF THE DRAWING

[0012] The present invention is now more closely explained using the attached drawing that schematically reproduces a transmitting part and a receiving part of an inventive hearing device. However, the subsequently specified embodiment thereby represents only one preferred embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] According to the schematic depiction in the Figure, the radio device of the inventive hearing device comprises a transmitter circuit 1, an antenna circuit 2, and a receiver circuit 3. A data processing unit configured as a transmission control and interface 4 is connected to the receiver circuit 3. The transmitter circuit 1 comprises an amplifier 11 that is connected via a switch S1 to the antenna circuit 2. To transmit, the switch S1 is closed and excites the antenna circuit 2 (that comprises a parallel circuit of a coil L1 and a capacitor C1) with resonance frequency via corresponding feedback with the amplifier 11.

[0014] A series connection made of a capacitor C2 and a switch S2 is connected in parallel to the amplifier 11. In the case that the capacitor C2 is hooked up to the capacitor C1, the resonance capacitance rises, whereby the resonance

frequency is lowered. The resonance frequency can thus be varied with the aid of the switch S2.

[0015] The coil L1 in the antenna resonance circuit 2 enables a good radiation in the long-wave range. In the case that the switch S2 is now switched in time to the transmitted data, a corresponding frequency-modulated data signal is wirelessly radiated by the coil L1.

[0016] A compact oscillation circuit can be realized in a very small overall space via the use of the LC antenna circuit 2. Moreover, the oscillation circuit 2 can be operated with relatively low power, since it needs to be activated only briefly by the amplifier 11. Only the energy that is lost via the radiation of the coil L1 needs to be supplied.

[0017] The receiver circuit 3 is likewise connected to the antenna circuit 2. If the antenna circuit 2 functions as a receiver, the signal in a receiver circuit 3 is first preamplified in a preamplifier 31 and subsequently supplied to a bandpass filter 32. Freed of unnoticeable frequency portions, the signal is further amplified in an amplification 33, and, if necessary, further processed and supplied to a median filter 34. This median filter 34 filters the average from, for example, five values and therewith provides a very good suppression or, respectively, reduction of noises. The output of the median filters 34 is connected with an evaluation unit 35. From the output of the evaluation unit 35, the receiver signal exits the receiver circuit 3 and is transmitted to a device for further processing that, for example, provides transmission control or presents an interface.

[0018] The resonance frequency of the antenna oscillator as a carrier frequency and also a corresponding bit timing is transmitted with the antenna oscillator 2 connected between the transmission part 1 and the receiving part 3. The receiving part 3 connected with a high resistance to the antenna circuit 2 is always active and, in addition to the bit timing, also derives from the receiver signal the information transmitted via frequency modulation.

[0019] The receiving part or, respectively, the receiver circuit 3 is therefore able to ensure for hearing devices a narrow-band information transmission from the low-energy inductively transmitted signal, with a suitable reduction of noise signals.

[0020] For the purposes of promoting an understanding of the principles of the invention, reference has been made to the preferred embodiments illustrated in the drawings, and specific language has been used to describe these embodiments. However, no limitation of the scope of the invention is intended by this specific language, and the invention should be construed to encompass all embodiments that would normally occur to one of ordinary skill in the art.

[0021] The particular implementations shown and described herein are illustrative examples of the invention and are not intended to otherwise limit the scope of the invention in any way. For the sake of brevity, conventional electronics, control systems and other functional aspects of the systems (and components of the individual operating components of the systems) may not be described in detail. Furthermore, the connecting lines, or connectors shown in the various figures presented are intended to represent exemplary functional relationships and/or physical or logical couplings between the various elements. It should be noted that many alternative or additional functional relationships, physical connections or logical connections may be present in a practical device. Moreover, no item or component is essential to the practice of the invention unless the element is specifically described as "essential" or "critical". Numerous modifications and adaptations will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.

#### REFERENCE LIST

- 1 transmission circuit
- 2 antenna circuit
- 3 receiver circuit
- 4 data processing unit
- 11, 33 amplifier
- 31 preamplifier

32 bandpass filter

34 median filter

35 evaluation unit

C1, C2 capacitors

L1 coil

S1, S2 switches